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PROVISIONAL APPLICATION

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By: Elaine Elzinga

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Sir:

Transmitted herewith for filing is a provisional patent application under 37 CFR 1.53(b)(2) of:

LAST NAME	FIRST NAME	MIDDLE INITIAL	RESIDENCE (CITY/STATE/COUNTRY)
Flamm	Daniel	L.	Walnut Creek, California, United States

Title: **MULTI-TEMPERATURE PLASMA ETCHING PROCESS**

Enclosed are:
[X] 29 pages of the specification.
[X] 3 pages of claims.
[X] 1 pages of abstract.
[X] 12 sheet(s) of informal drawing(s).
[X] 1 Exhibit.
[ ] A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27.
[ ] The invention was made by or under a contract with the following agency of the United States Government: ______ under Government contract number: ______.
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Respectfully submitted,

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16655-000800

PROVISIONAL PATENT APPLICATION

MULTI-TEMPERATURE PLASMA ETCHING PROCESS

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Entity Status:

Small

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METHOD AND DEVICE MADE BY PLASMA ETCHING

CROSS-REFERENCE TO RELATED APPLICATIONS

This present application is a continuation-in-part of U.S. Application Serial No. 08/567,224 filed December 4, 1995 (Attorney Docket No. 16655-5), which is hereby incorporated by reference for all purposes.

BACKGROUND OF THE INVENTION

This invention relates generally to plasma processing. More particularly, one aspect of the invention is for greatly improved plasma processing of devices using an inductive discharge. Another aspect of the invention is illustrated in an example with regard to plasma etching or resist stripping used in the manufacture of semiconductor devices. The invention is also of benefit in plasma assisted chemical vapor deposition (CVD) for the manufacture of semiconductor devices. But it will be recognized that the invention has a wider range of applicability. Merely by way of example, the invention also can be applied in other plasma etching applications, and deposition of materials such as silicon, silicon dioxide, silicon nitride, polysilicon, among others.

Plasma processing techniques can occur in a variety of semiconductor manufacturing processes. Examples of plasma processing techniques occur in chemical dry etching (CDE), ion-assisted etching (IAE), and plasma enhanced chemical vapor deposition (PECVD), including remote plasma deposition (RPCVD) and ion-assisted plasma enhanced chemical vapor deposition (IAPECVD). These plasma processing techniques often rely upon radio frequency power (rf) supplied to an inductive coil for providing power to gas phase species in forming a plasma.

Plasmas can be used to form neutral species (i.e., uncharged) for purposes of removing or forming films in the manufacture of integrated circuit devices. For instance, chemical dry etching generally depends on gas-surface reactions involving these neutral species without substantial ion bombardment.

In a number of manufacturing processes, ion bombardment to substrate surfaces is often undesirable. This ion bombardment, however, is known to have harmful effects on properties of material layers in devices and excessive ion bombardment flux and energy can lead to intermixing of materials in adjacent device layers, breaking down oxide and "wear out," injecting of contaminative material formed in the processing environment into substrate material layers, harmful changes in substrate morphology (e.g. amophotization), etc.

Ion assisted etching processes, however, rely upon ion bombardment to the substrate surface in defining selected films. But these ion assisted etching processes commonly have a lower selectivity relative to conventional CDE processes. Hence, CDE is often chosen when high selectivity is desired and ion bombardment to substrates are to be avoided.

One commonly used chemical dry etching technique is conventional plasma assisted photoresist stripping, often termed ashing or stripping. Conventional resist stripping relies upon a reaction between a neutral gas phase species and a surface material layer, typically for removal. This reaction generally forms volatile products with the surface material layer for its removal. The neutral gas phase species is formed by a plasma discharge. This plasma discharge can be sustained by an inductive applicator (e.g., a helical coil) operating at a selected frequency in a conventional photoresist stripper. An example of the conventional photoresist stripper is a quarter-wave helical resonator stripper, which is described by U.S. Patent No. 4,368,092 in the name of Steinberg et al.

Among the pervasive applications of patterned photoresist in device fabrication is their use as an ion implantation mask to shield selected areas from unwanted ion implantation. Unfortunately when ions bombard the mask an unwanted result is often modification of the near surface region of the mask by the ion beam. In particular, ions striking the mask break chemical bonds within the photoresist and cross-link polymer chains in regions they penetrate while eliminating hydrogen that is bonded to the polymer backbone. Moreover, many of the ions striking the resist mask are implanted into the resist. These processes result in a hardened, more highly cross-linked and relatively impermeable near surface zone of resist (a "crust" of more diamond-like carbon), which overlies the original patterned resist material. This cross-linked layer is undesirable from a processing point of view because it etches more slowly than the underlying material and is less permeable to low molecular weight monomer and residual solvent within the photoresist matrix.

Ideally the etch rate could be increased to compensate for this effect by heating the resist and substrate. Unfortunately, when a cross-linked crust is present, the processing temperature must be limited to avoid undue vapor pressure of solvent and monomeric material within the resist. If an excessive temperature is used to achieve and increased rate of resist stripping, the pressure of volatile solvent and low molecular weight residue within the resist matrix often increases and ruptures the hardened crust when it is thinned by etching. This phenomena has been termed "popping" and it is impermissible because it generates harmful contaminative particulate matter.

Unimplanted resist does not suffer this problem as great an extent for several reasons. One reason is that it is more easily etched by an oxygen plasma and can therefore be removed by treatment at a lower temperature. An addition reason is that the near surface region of unimplanted resist is more permeable and elastic, hence allows volatile material to escape more easily. In some processes another limitation on maximum permissible resist stripping temperature stems from the fact that wafer temperature must be maintained below about 180°C to avoid the degradation of antireflection layers. Hence there is a need for a fast etching process which is capable of removing an ion-implanted resist crust at relatively low temperatures.

Referring to the above, an objective in chemical dry etching is to reduce or even eliminate ion bombardment (or ion flux) to surfaces being processed to avoid damaging the substrate and to maintain the desired etching selectivity. In practice, however, ideal chemical dry etching often difficult to achieve using conventional techniques. These conventional techniques generally attempt to control ion flux by suppressing the amount of charged species in the plasma source reaching the process chamber. A variety of techniques for suppressing these charged species have been proposed.

These techniques often rely upon shields, baffles, large separation distances between the plasma source and the chamber, or the like, placed between the plasma source and the process chamber. The conventional techniques generally attempt to directly suppress charge density downstream of the plasma source by interfering with convective and diffusive transport of charged species. They tend to promote

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